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Properties of Some Indian Rocks at X-band Region of Microwave

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ABSTRACT

The purpose of this study is to investigate the electrical properties of some rocks at X-band for remote sensing. Slotted wave-guide transmission line method was used to take the observation for dry and water saturated rocks. The reflection coefficients, of the four different types of rocks are studied. The rocks used in this study were collected from different parts of the India; details of the rocks are shown in table 1.

Keywords: Electrical properties of rocks, X-band, Remote sensing.

1. INTRODUCTION

The study of frequency dependence of electrical properties of rocks has been an active topic of research. Many researchers have done much of work in recent years to develop theoretical as well as empirical models, which are applicable to wide range of rocks types, water conductivity, and tool frequencies (Berg 1995, Frasch *et al* 1998) .The study of the electrical properties of the rocks is also useful in calculation of earth effect on transmission system (Sunde 1968, Keller *et al*. 1966).The rocks used for this studied was collected from different part of India. Details of the samples are:

Sample 1. Auriferous quartz is a gold bearing ore. Quartz is highly sheared and granular. In this ore, total sulphides and oxides together are less then 1 %. This rock is ore found at Hutti, Rajsthan.

Sample 2. It is a heard and compact rock type with quartz, feldspars and muscovite as the essential minerals. Chemically the rock type is having high concentration of silica and Aluminum (~70%). This is a principle mineral for the manufacture of glass and ceramic products.

Sample 3. This is a metamorphosed basic rock having fine grain texture and mainly composed of clay sized particles. This rock is closely associated with thick copper ore body at Khetri in Rajsthan

Sample 4. This is a compact and hard verity of lead and zinc mineralized ore body. The

minerals composition is galena (PbS) and sphalerite (ZnS). Associated impurities are quartz and calcite. This body is occurring with metamorphosed limestone at Zawar, Rajsthan.

Slotted wave-guide transmission line method is used for observations. The setup requires the availability of the brick shaped sample, which can be obtained by cut the sample with diamond lapidary.

II. SAMPLE PREPARATION AND EXPERIMENTAL PROCEDURE

A. Sample Preparation

The Rocks were obtained as an irregular, arbitrarily shaped having no linear dimensions. The rocks samples were cut with a diamond lapidary saw into 2.2 cm x 1cm x 0.65 cm size. During the cutting process, spraying water on to the cutting surface of the saw cooled the saw blade and rock.

B. Slotted Wave-guide Transmission Line Method

Slotted wave-guide transmission line technique has been used for the estimation of dielectric constant and loss tangent for varying moisture contents at X-band. For this estimations a two-point method of measurement given by, Sucher and Fox 1963, was applied. Stones samples have been carefully cut in size and gently grounded to fit in the wave guide.

Firstly, the slotted line was adjusted to a short circuit length of the wave guide. Now the sample is inserted into the wave guide so that one end of the sample touches the short- circuited end of the wave guide. By using double minimum method (Sucher and Fox, 1963), for each position of samples in the wave guide the corresponding position of the first voltage minimum has been accurately determined. The position of the voltage minimum, when the short circuited wave guide empty was measured. The shift in minimum gives measure of dielectric constant where as the decrease in standing wave ratio gives measure of loss tangent. In terms of lumped wave guide parameters of the interposed stones samples and its measured response to microwaves, the relative dielectric constant and the loss tangent are written as

$$\varepsilon' = \left(\frac{x\lambda_o}{2\pi l}\right)^2 + \left(\frac{\lambda_o}{\lambda_c}\right)^2 \tag{1}$$

$$\tan\delta = \frac{d_1 - d_2}{\varepsilon'\left(\lambda_o/\lambda_g\right)^2} \tag{2}$$

$$\frac{\tan x}{x} = \frac{\lambda_g}{2\pi l}\tan\frac{2\pi(l+d)}{\lambda_g} \tag{3}$$

where λ_c (Cut of wave length) = 2a,a- being the width of the rectangular wave guide, λ_g - wave guide wavelength without specimen., λ_o - free space wave length, l - length of specimen, d - shift in the position of minima, d_1 - distance between 3 dB points without specimen., d_2 - distance between 3dB points with specimen.

C. Moisture Measurement

Reflection cofficient of the stones samples at various moisture contents has been measured. The sample slowly heated to 110^0 C and Cooled down to the room temperature have been said to be dry. To prepare wet sample, they were soaked 24 hours in distilled water. The percentage water saturation of the rocks are calculated by

$$\%\text{Watersaturation}=\frac{R_W - R_D}{W}\times 100 \qquad (4)$$

where R_W is the weight of the wet rock sample, R_D is the weight of the dry rock sample, W is the difference of the weight of saturated rock (after socked 24 hours in distilled water) and dry rock.

III. EXPERIMENTAL RESULTS

Using the measured parameters, the reflection coefficient of the rocks samples has been computed in the X- band of the microwave. The reflection coefficient is seen to decrease slowly with increasing frequency as shown in figures 1, 2,3 and 4 for all the four types of rocks samples (1,2,3,4). Almost similar frequency variations are shown by the water saturated and dry sample. The reflection coefficient decreases as the percentage water contents increase in all the four rocks.

TABLE I DETAILS OF THE ROCKS

Sample No.	Rocks Details	Chemical Composition	Occurrences
Sample 1	Auriferous Quartz	SiO_2,Biotite mica, sulfide minerals,Gold	Hutti, Karnatka
Sample 2	Leucogranite	SiO_2 , Silactes (Sodium, Potassium, Aluminium Silicates) magnetite, ilmenite, aluminium borosilicate	Sewariya, Govind Gargh area of Rajsthan
Sample 3	Metamorphosed copper ore(Chalcopyrite)	SiO_2 ,$CuFeS_2$	Khetri Rajsthan
Sample 4	Galena ore	SiO_2 ,$CaCO_3$, PbS,ZnS	Zawar, Rajsthan

TABLE II. DENSITY OF SOME MINERAL

Minerals Name	Density (g / cm^3)
Galena(PbS)	7.61
Quartz(SiO_2)	2.648
Sphalerite(ZnS)	4.097
Chalcopyrite($CuFeS_2$)	4.2

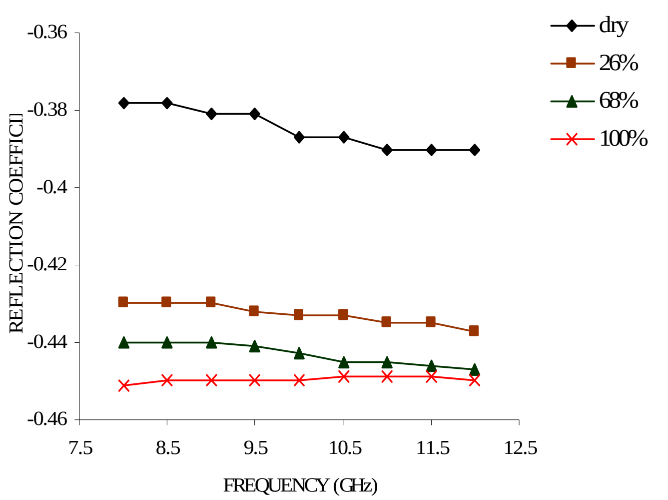

Fig.1 Variation of reflection coefficient with frequency at different moisture (sample-1)

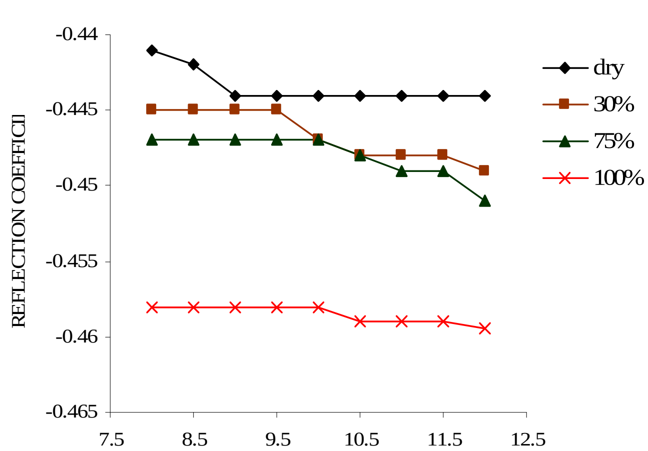

FIG. 2 Variation of reflection coefficient with frequency at different moisture (sample -2)

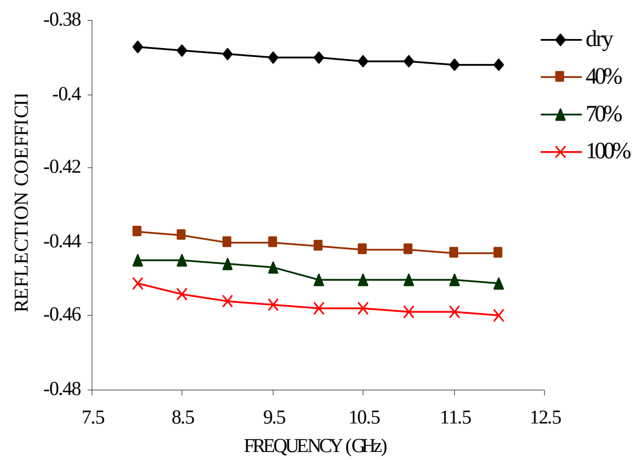

FIG.3.Variation of reflection coefficient with frequency at different moisture (sample-3)

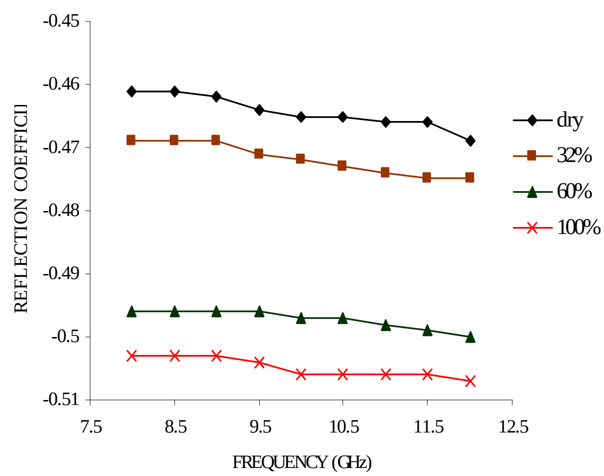

FIG. 4. Variation of reflection coefficient with frequency at different moisture (sample-4)

IV. CONCLUSIONS

The reflection coefficient of the rocks sample for X-band frequency has been calculated, and its value seen to decrease as we increase frequency. This experiment study also illustrates the importance of the chemical composition of the rocks in determining the dielectric behavior of rocks.

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